DEC 3 1970

Cost-Analysis of Genetic Disease from Radiation:

$100 per man-rad

(present value of its future costs)

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For purposes of discussion the radiation background is taken to be 0.1 rad per year. This is consensually estimated to account for 10% of our load of mutational damage. Since there is general agreement that the genetic effects of radiation outweigh all the others, this may give a convenient if somewhat oversimplified yard-stick for a cost benefit analysis.

We will say then that doubling the background would increase the rate of mutation by about 10%. There are only minor quarrels about the extent to which mutational damage might be decreased at very low dose rates and there are balancing counter-arguments about the interaction of radiation with other pollutants.

To estimate the health cost of that increase in mutation rate requires a judgement of

1. the economic cost of imperfect health
2. the fraction of this attributable to genetic defect
3. the relationship of increased mutation rate to prevalance of genetic impairment.

1. Assume that the total burden of ill health costs (the U.S.) about $200 billion today. Direct health care alone approaches $80 billion. The extrapolation from 80 to 200 is a crude intuition based on the following considerations:

a) Hardly anyone, even if he invests five times the mean value, believes he is getting a bad bargain in expenditures to protect himself.

b) Large segments of the population now receive acknowledgedly poor standards of health care.

c) Health care is a small fraction of the economic burden of marginal health. The figure of $200 billion is intended to estimate the difference between our existing national productivity and what would obtain if every individual enjoyed the highest credible level robust good health. Most of the real cost of health impairment probably derives from the reduced efficiency of people who are nominally "healthy" but are, in fact, significantly impaired. Part of the enormous costs of social and political conflict that may be connected with deviations in physical and mental health might be added to this estimate.

2. The considerable heritable component of many common diseases, taken together with the strong and clear genetic component of many other handicaps, suggests that as much as 50% of our health burden can be attributed to genetic difficulties. This assumption states that, if the entire population enjoyed

an <u>optimal</u> genotype, including factors that bear on cardiovascular disease, diabetes, cancer, and mental disease, our health bill would be reduced by at least half.

3. For sake of argument I will postulate a direct linear relationship between the mutation rate and the prevalence of genetic defect. This states that after a period of several generations to reach equilibrium a doubling of the mutation rate would result in a doubling of the genetic load.

We can then make a simple calculation. At 10% increase in mutation rate would eventually give rise to an increase in health cost of 10%, times $200 billion (total health cost),times 1/2 (the genetic component of disease). This product (0.1 x 200B x 0.5) comes to $10 billion per annum. With a population of about 200 million people this works out to an increase in annual health cost of $50 per person for an increase in radiation exposure of 0.1 rad per annum. We thus come to $500 per man-rad as the eventual cost of radiation exposure.

However, most of this bill is deferred for future payment, since many genetic defects are in recessive mutant genes. These are latent until reshuffled in the population so that a child receives one from each of his two parents. The time course of expression of new mutations is an extremely complicated calculation. Most authors have assumed an interval of 5 to 10 generations for most of that payment to be imposed.

Should we do a formal discount analysis of such a future cost?

At a 6% discount rate a cost of $500 one hundred years hence would have a present value of only $1.47. On the other hand, the economic cost of health (and intellectual) impairment will also be increasing with time at a rate that must also be discounted. Furthermore, a fair portion of the cost will be expressed in earlier generations as dominant and semi-dominant effects and chromosome aberration.

Having exposed these assumptions I will put 1/5 of $500, or $100 per man-rad, as a reasonable estimate of the present value of future genetic costs of radiation.

These costs can surely be mitigated by compensatory research in radiation biology and in fundamental genetics, but only if it is adequately funded and vigorously pursued. A possible policy approach to this question would be to tax the use of nuclear energy for the benefit of such compensatory research, and for the care of more proximate victims, to the extent that the costs of side-effect exposure to radiation can be estimated. This suggestion is not to exculpate pollution stemming from fossil fuels from a similar redress.

· 2% may be more appropriate to the present analysis. This allows 2% increase in perceived value of health (which includes individual productivity) and 2% in population at risk. Present value would then be $500/((1.02)^{100} = \$69.$

Footnotes and Critical Comments

The estimation of the cost of ill health is extremely precarious since so much of it involves values that are beyond conventional economic analysis and are outside the customary marketplace. "The value of a life" cannot be taken merely as the present value of his future earnings if for no other reason than that a considerable part of those earnings are applied to the consumption of resources and other products. The same consideration applies to the expected tax yield from an individual's economic activity. The attempt to do a cost benefit analysis of human life resembles a similar attempt to analyze the values of government and of society, and is indeed inextricably connected with these issues. One can ask "what would a reasonable person pay for an incremental improvement in his own health, if this could be purchased on the marketplace". This answer would necessarily be a function of his general economic situation but we might then also attempt to make some predictions of the future distribution of economic wealth. This approach would give at least a minimum estimate of the economic value of health. It is minimal in so far as so many aspects of good health are byond purchase or appear to be in the present technical and social context.

We would then also have to consider the relationship between the social and the individual valuation of this price.

From a technical standpoint the most contentious postulate may be the one assumed in paragraph #3. The mutation rate surely does not account for the entire genetic load. There may be no single optimal genotype, in the sense that robust health in one arena may be unavoidably associated with deficits in another. Furthermore, many genetic defects undoubtedly are a result of segregation from heterozygotes which have more robust genotypes but will inevitably produce progeny with a range of biological competence. On the other hand, the cost of mutation may be expected to increase as we apply medical care towards the partial amelioration of genetic defect and, for example, countermand the natural selection that helps to keep mutants in balance in the population. (There is then a certain cost associated with the practice of medicine along the same lines as the present analysis of mutation.) The question of the relative importance of mutation and segregation from common polymorphisms is heatedly contested among geneticists today.

These considerations may suggest that the figure of $100 per man-rad is inflated. On the other hand, it totally ignores the non-genetic damage imposed by radiation whose present value may be comparable. All these considerations taken together, the proper value (which is partly a question of definition, partly a question of uncertain scientific fact) probably will be agreed to lie between $10 and $500 per man-rad.